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APPLIED HEALTH PHYSICS AND SAFETY ANNUAL REPORT FOR 1972

OAK RIDGE NATIONAL LABORATORY

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HEALTH PHYSICS DIVISION

APPLIED HEALTH PHYSICS AND SAFETY ANNUAL REPORT FOR 1972

J. A. Auxier, Director

D. M. Davis, Assistant Director

W. S. Snyder, Assistant Director

SEPTEMBER 1973

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION

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*DUAL CAPACITY
†RADIATION CONTROL OFFICER DIVISION SAFETY OFFICER
[1]ENVIRONMENTAL SCIENCES
[2]REACTOR DIVISION
[3]CONSULTANT, OHIO WESLEYAN UNIVERSITY
[4]CONSULTANT, GEORGIA INSTITUTE OF TECHNOLOGY
[5]ON LOAN FROM MATHEMATICS DIVISION
[6]POSTDOCTORAL FELLOW
[7]ON LOAN TO ENVIRONMENTAL IMPACT STUDIES
[8]STUDENT
[9]VISITING PROFESSOR
[10]ALSO EDUCATION AND INFORMATION SECTION
[11]ORAU SUMMER FELLOW
[12]CONSULTANT, UNIVERSITY OF TENNESSEE
[13]ALIEN GUEST
[14]CONSULTANT
[15]MEDICAL PHYSICS AND INTERNAL DOSIMETRY
[16]TENNESSEE A&I
[17]PLANT AND EQUIPMENT DIVISION
[18]INSTRUMENTATION AND CONTROLS DIVISION
[19]NEUTRON PHYSICS DIVISION

YSICS DIVISION

LY 1, 1972

IRECTOR
R,* ASSISTANT DIRECTOR
*ASSISTANT DIRECTOR

JEANNE S. CARVER
GWEN L. DAGLEY

OUTSIDE ASSIGNMENTS

K. E. COWSER
B. L. HOUSER
D. G. JACOBS

SENIOR RESEARCH ADVISORS

K. Z. MORGAN
E. P. WIGNER

LOPMENT

ER*

ENCE

IST

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ACT

R.

FUNDAMENTAL HEALTH PHYSICS RESEARCH

R. D. BIRKHOFF
R. H. RITCHIE

TECHNICAL SUPPORT

ADA E. CARTER
J. A. HARTER
D. PITTMAN

DESIGN ENGINEER

J. T. COX

SECRETARIAL SERVICES

NORMA BRASHIER*
NATALIE TARR
BEVERLY VARNADORE

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R. P. BLAUNSTEIN
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T. A. CALLCOTT
C. CHEN
R. A. MacRAE
J. NEUFELD
L. R. PAINTER
S. Y. SHIEH

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S. R. BERNARD*
L. T. DILLMAN[3]
B. R. FISH
M. R. FORD
S. M. GARRY[8]
J. P. HICKEY
M. J. C. HILYER
C. F. HOLOWAY*
T. D. JONES*
K. Z. MORGAN[4]
J. W. POSTON
P. S. STANSBURY[8]
F. C. VON DER LAGE[14]

URBAN GROWTH PATTERNS RESEARCH

R. C. TAEUBER
JEAN A. KEIL
BRENDA RUTHERFORD
LINDA C. SPARKS
PHYLLIS B. ZUSCHNEID

B. L. BISHOP
R. A. BOHM[14]
R. E. KEMPER
E. S. LEE[14]
M. L. LEVIN[14]
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C. H. PATRICK
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P. D. POSTMA
P. N. RITCHEY[14]
R. B. STURGIS[14]
M. M. WILLIAMS[14]

ENVIRONMENTAL REPORTS PROJECT

E. G. STRUXNESS[1]

RADIOLOGICAL IMPACT

D. R. NELSON*
H. H. ABEE*
T. J. BURNETT*
T. G. CLARK*
C. E. EASTERLY*
S. V. KAYE[1]
M. J. KELLY[2]
P. S. ROHWER[1]

CIVIL DEFENSE RESEARCH

C. V. CHESTER
MARGARET CHRISMON
JUDY B. SNOW

STRATEGIC DEFENSE

G. A. CRISTY
C. B. BROOKS
R. O. CHESTER
J. S. GAILAR
C. M. HAALAND
C. H. KEARNY

ELECTROMAGNETIC PULSE

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J. K. BAIRD
P. R. BARNES
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M. F. FAIR*
J. C. HART*
C. F. HOLOWAY*

1.0 ORGANIZATION CHART

2.0 SUMMARY

This report describes and summarizes the activities of the applied sections of the Health Physics Division, i.e., Radiation Monitoring, Radiation and Safety Surveys, and Safety Engineering and Special Projects for calendar year 1972. Projects and activities within the research sections are described in ORNL-4811, Health Physics Division Annual Progress Report, Period Ending July 31, 1972.

There were no external or internal exposures to personnel which exceeded the standards for radiation protection as defined in AEC Manual Chapter 0524.

There were no accidental releases of gaseous or liquid waste from the Laboratory which were of a level that required an incident report to the AEC.

Eleven unusual occurrences involving radioactive materials were recorded during 1972. This was one more than the 10 recorded for 1971. However, the 10 recorded in 1971 was the second lowest number since the system of reporting unusual occurrences was established in 1960. The average number reported for the past five years (1967–1971) was 13.4.

The safety record for 1972 was good as compared with industry standards but was poor by comparison with ORNL's recent past performance. Although the total number of Medical Treatment Cases as compared with 1971 decreased by 37, the number of Serious Injuries for the year (1972) increased by 11 and the number of Disabling Injuries increased by three. The Disabling Injury frequency rate for 1972 was 1.08 as compared with a frequency rate of 0.61 for 1971.

3.0 RADIATION MONITORING

3.1 Personnel Monitoring

All persons who enter Laboratory areas where there is a likelihood of exposure to radiation or radioactive materials are monitored for the kinds of exposure they are likely to sustain. External radiation dosimetry is accomplished mainly by means of film badges, pocket ion chambers, and hand exposure meters. Internal exposure is determined from bio-assays and in vivo counting.

3.1.1 Dose Analysis Summary, 1972

(a) External Exposures - No employee received a whole body radiation dose which exceeded the standards for radiation protection, AEC Manual Chapter 0524. The maximum whole body exposure dose received by an employee was about 4.88 rem or 40 percent of the maximum permissible annual dose. The range of doses to persons using ORNL badge-meters is shown in Table 3.1.1, page 12.

As of December 31, 1972, each employee had a cumulative whole body dose which was less than the recommended maximum permissible value based on the age proration formula 5(N-18) (Table 3.1.2, page 12). No employee had an average annual exposure rate that exceeded 5 rem per year of employment (Table 3.1.3, page 12). The greatest cumulative dose of whole body radiation received by an employee was approximately 99 rem. This dose was accrued over an employment period of about 29 years and represented an average exposure of about 3.4 rem per year.

The greatest cumulative dose to the skin of the whole body received by an employee during 1972 was about 10 rem or 33 percent of the maximum permissible annual skin dose of 30 rem.

The maximum cumulative hand exposure recorded during 1972 was about 52 rem or 69 percent of the recommended maximum permissible annual dose to the extremities.

The average of the 10 greatest whole body doses to ORNL employees for each of the years 1968 through 1972 is shown in Table 3.1.4, page 13. The maximum individual dose for each of those years is shown, also.

(b) Internal Exposures - There was one case of internal exposure for which the deposition of radioactive materials within the body may have averaged as much as one-half of the maximum permissible body burden for the year.

Four employees have estimated body burdens of transuranic alpha emitters slightly less than 50 percent of the recommended maximum permissible value.[1] The ICRP recommends, Publication 6, paragraph 86(a), that individuals who exceed 50 percent of a maximum permissible body burden be placed on a work assignment where the potential for internal exposure is reduced.

3.1.2 External Dose Techniques

(a) Film Meters - Film meters are issued to all persons who have access to ORNL facilities in which there is a likelihood of radiation exposures for which monitoring is required. Photo-badge-meters are assigned to all ORNL employees and to certain other persons who are authorized to enter ORNL facilities. Temporary meters may be issued in lieu of photo-badge-meters for short-term use.

NTA (nuclear track) film packets are included in all film meters. The NTA films are processed routinely if the badge-meter is assigned to an individual who normally works where there may be exposure to neutrons; otherwise the films would be processed only in the event of a nuclear accident.

Beta-gamma sensitive films from badge-meters issued to full-time employees are processed routinely each calendar quarter (or more frequently, if necessary). Films used in other meters are processed as conditions of use may require. Films from meters issued to visitors are processed if there is a likelihood that a radiation exposure was incurred.

High-level radiation dosimetry components of the badge-meters (sulfur, gold, indium, and metaphosphate glass) are for use in the event that doses exceed the capability of the monitoring films.

Thermoluminescent dosimeters, TLD-100 ribbons, are included in badge-meters of persons who are likely to sustain significant exposures, particularly to lower energy photons.

(b) Pocket Meters - Pocket meters (indirect reading, ionization chambers) are made available at all principal points of entry to ORNL premises. A pair of pocket meters is carried for the duration of a work shift by persons who work in an area where the potential for an exposure of 20 mR or more exists during the work shift. Pocket meter pairs are processed each day by Health Physics technicians and readings of 20 mR or more are reported daily to supervision. Pocket meters are used for a day-to-day record of integrated exposure.

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[1]AEC Manual Chapter 0502 requires an evaluation of the radiation exposure status of an employee when monitoring techniques indicate that a body burden equals or exceeds 50 percent of a maximum permissible limit.

(c) Hand Exposure Meters - Hand exposure meters are TLD-loaded finger rings used to measure hand exposure. Hand exposure meters are issued to persons for use during operations where it is likely that the hand dose is such as to exceed 1 rem during the week. They are issued and collected by Radiation and Safety Surveys personnel who determine the need for this type of monitoring and arrange for a processing schedule.

(d) Metering Résumé - Shown in Table 3.1.5, page 14, are the quantities of personnel metering devices used and processed during 1972. The number of films processed is less than the number issued, because those which are issued for accident dosimetry only are not processed unless there is a likelihood of exposure.

3.1.3 Internal Dose Techniques

(a) Bio-Assay - Urine and fecal samples are analyzed for the purpose of making internal dose determinations. The frequency of sampling and the type of radiochemical analysis performed are based upon each specific radioisotope and the exposure potential. Because of the small quantities of radioactive material in most samples, qualitative analyses are not feasible, and only quantitative analyses for predetermined isotopes are performed routinely.

In most cases bio-assay data require interpretation to determine the dose to the person; computer programs are used for evaluation of extensive data on urinary excretion of ^{239}Pu. An estimate of dose is made for all cases in which it appears that one-fourth of a body burden, averaged over a calendar year, may be exceeded.

The analyses performed by the Applied Health Physics and Safety Radiochemical Lab during 1972 are summarized in Table 3.1.6, page 15.

(b) Whole Body Counter - The Whole Body Counter (an in vivo gamma spectrometer) may be used for determining internally deposited quantities of most radionuclides which emit photons.

During the calendar year 1972 there were 272 whole body or thorax counts of ORNL employees. No detectable activity of significance relatable to ORNL exposure was found.

(c) Counting Facility - The Applied Health Physics and Safety counting facility determines radioactivity content of samples submitted by groups within the Department. A summary of analyses is in Table 3.1.7, page 16.

3.1.4 Reports

Routine reports of personnel monitoring data are prepared and distributed to divisional supervision and to Applied Health Physics and Safety staff.

(a) Pocket Meter Data – A report is prepared daily of the names, ORNL division, and readings for pocket meter readings which were 20 mR or greater during the previous 24 hours.

A computer-prepared report, which includes all pocket meter data for the previous week, and summary data for the calendar quarter, is published and distributed weekly.

(b) External Dosimetry Data – A computer-prepared report, which includes data of recorded skin dose and whole body dose for the previous calendar quarter and totals for the current year, is published and distributed quarterly.

(c) Bio-Assay Data – A computer-prepared report, which includes data of sample status and results for the previous week, is published and distributed weekly. A quarterly and an annual report of results are prepared and distributed.

(d) Whole Body Counter Data – Preliminary results of analysis are reported on a card form soon after counting is done.

A computer-prepared report, which includes data collected during the previous calendar quarters of the calendar year, is published and distributed quarterly.

3.1.5 Records

Permanent records of personnel monitoring data are maintained for each person who is assigned an ORNL photo-badge-meter.

3.2 Environs Monitoring

The Health Physics Division monitors for airborne radioactivity in the East Tennessee area by the use of three separate monitoring networks. The local air monitoring (LAM) network consists of 22 stations which are positioned in the vicinity of ORNL operational activities; the perimeter air monitoring (PAM) network consists of nine stations which are located near the perimeter of the AEC-controlled area; and the remote air monitoring (RAM) network consists of eight stations which are located outside the AEC-controlled area at distances of from 12 to 75 miles from ORNL.[2] The monitoring networks provide for the collection of (1) airborne radioactivity by air filtration techniques, (2) radioparticulate fallout material by impingement on gummed paper trays, and (3) rainwater for measurement of fallout occurring as rainout.

Low-level radioactive liquid wastes originating from ORNL operations are discharged, after preliminary treatment, to White Oak Creek, which is a small tributary

[2]For maps showing location of station, see ORNL-4423, Applied Health Physics and Safety Annual Report for 1968.

of the Clinch River. The radioactive content of White Oak Creek discharge is determined at White Oak Dam which is the last control point along the stream prior to entry of White Oak Creek waters into Clinch River waters. Water samples are collected also at a number of locations along the Clinch River, beginning at a point above the entry of waste into the River via White Oak Creek and ending at Center's Ferry (near Kingston, Tennessee) about 16 miles downstream from the confluence of White Oak Creek and the Clinch River. Water samples are analyzed for gross radioactivity and for specific radionuclides present in detectable quantities. The concentration of each nuclide detected is compared with its respective MPC_w value, as specified by AEC Manual Chapter 0524, and the resulting fractions summed to arrive at the percent MPC_w in the Clinch River.

Samples of ORNL potable water are collected daily, composited and stored. At the end of each quarter these composites are analyzed radiochemically for ^{90}Sr content and are assayed for long-lived gamma-emitting radionuclides by gamma spectrometry.

Raw milk samples are collected at 12 sampling stations located within a radius of 50 miles from ORNL. Samples are taken on a weekly basis from eight stations which are located outside the AEC-controlled area within a 12-mile radius of ORNL. Samples are collected every five weeks from the four remaining stations, all of which are located outside the 12-mile radius up to distances of about 50 miles. The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of ORNL provide data by which one may evaluate the possible effect of waste releases originating from ORNL operations; second, samples collected remote to the immediate vicinity of ORNL provide background data which are essential in establishing a proper index from which releases of radioactive materials originating from Oak Ridge operations may be evaluated.

Background gamma radiation measurements are made at a number of locations in the East Tennessee area. These measurements are taken with calibrated G-M and scintillation-type detectors at a distance of three feet above the surface of the ground.

Fish from the Clinch River are sampled during the spring and summer and analyzed for their radioactive content. The radionuclide concentrations in fish are related quantitatively to potential human intake of radioactivity through consumption of fish.

3.2.1 Atmospheric Monitoring

(a) Air Concentrations - The average concentrations of beta radioactivity in the atmosphere, as measured with filters from the LAM, PAM, and RAM networks during 1972, were as follows:

Network	Concentration (μCi/cc)
LAM	13×10^{-14}
PAM	7.9×10^{-14}
RAM	8.4×10^{-14}

The LAM network value of 13×10^{-14} μCi/cc is less than 0.01 percent of the $MPCU_a$[3] based on occupational exposure of 3×10^{-9} μCi/cc. Both the PAM and RAM network values represent ~ 0.1 percent of the $MPCU_a$ of 1×10^{-10} μCi/cc applicable to releases to uncontrolled areas. A tabulation of data for each station in each network is given in Table 3.2.1, page 17. The weekly values for each network are illustrated in Table 3.2.2, page 18.

(b) Fallout (Gummed Paper Technique) - Radioparticulate fallout as measured by the LAM, PAM, and RAM networks did not change significantly from the values observed in 1971. Table 3.2.3, page 19, presents a tabulation of the average concentration measured at each station within each network. Table 3.2.4, page 20, gives the average concentration for each network by weeks.

(c) Rainout (Gross Analysis of Rainwater) - The average concentration of radioactivity in rainwater collected from the three networks during 1972 was as follows:

Network	Concentration (μCi/cc)
LAM	1.8×10^{-8}
PAM	1.8×10^{-8}
RAM	2.2×10^{-8}

The average concentration in each network was about one-third the values observed during 1971. The average concentration measured at each station within each network is presented in Table 3.2.5, page 21. The average concentration for each network for each week is given in Table 3.2.6, page 22.

(d) Atmospheric Radioiodine (Charcoal Cartridge Technique) - Atmospheric iodine sampled at the perimeter stations averaged 1.1×10^{-14} μCi/cc during 1972. This average represents about 0.01 percent of the maximum permissible inhalation concentration of 1×10^{-10} μCi/cc applicable to ^{131}I released to uncontrolled areas.

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[3]The $MPCU_a$ is defined as the maximum permissible concentration for an unknown mixture of radioisotopes in air. AEC Manual Chapter 0524, Appendix, Annex 1, gives exposure values applicable to various mixtures of radionuclides and establishes guide lines for deriving the $MPCU_a$.

The maximum concentration observed at any one station for one week was 6.6×10^{-14} $\mu Ci/cc$, at PAM 35, the perimeter station located at Blair Gate.

The average radioiodine concentration at the local stations was 3.7×10^{-14} $\mu Ci/cc$. This concentration is less than 0.01 percent of the maximum permissible inhalation concentration for occupational exposure. The maximum concentration at any one station for one week was 36×10^{-14} $\mu Ci/cc$, at LAM 4, located west of the Settling Basin.

Table 3.2.7, page 23, presents the ^{131}I weekly average concentration data for both the local area (LAM) and the perimeter area (PAM) air monitoring networks.

(e) Milk Analysis - The average concentration of ^{131}I in raw milk samples collected near ORNL (within 12-mile radius) during 1972 ranged between 1.7 and 11.4 pCi/l and the average of samples collected from stations located more remotely from ORNL ranged between 3.3 and 13.3 pCi/l. The upper and lower limits of the average values were obtained by equating all values which were less than the minimum detectable level, 10 pCi/l, to zero for the lower limit and to 10 pCi/l for the upper limit. Table 3.2.8, page 24, gives the quarterly average and maximum values obtained from samples collected near ORNL and remote from ORNL.

The average concentration of ^{90}Sr in raw milk samples collected near ORNL was 11 pCi/l. The average concentration in the samples collected remote from ORNL was 8.6 pCi/l. Table 3.2.9, page 24, presents the quarterly average and maximum values obtained from both sampling areas.

The yearly average values for both ^{131}I and ^{90}Sr fall within the limits of FRC Range I daily intake guides, if one assumes an intake of 1 liter of milk per day.

(f) ORNL Stack Releases - The ^{131}I releases from ORNL stacks are summarized in Table 3.2.10, page 25.

3.2.2 Water Monitoring

(a) White Oak Lake Waters - A total of 10,600 curies of tritium and about 8.8 beta curies of radioactivity other than tritium were released to the Clinch River during 1972 as compared with 8,900 curies of tritium and 8.6 beta curies of other radionuclides released in 1971. Yearly discharges of specific radionuclides to the Clinch River, 1967 through 1972, are shown in Table 3.2.11, page 26.

The calculated average concentrations of the significant radionuclides in the Clinch River at Clinch River Mile (CRM) 20.8 (the point of entry of White Oak Creek into the River) are presented in Table 3.2.12, page 27. The percent MPC_W did not exceed 0.6 percent for any month during 1972 (Table 3.2.13, page 28).

(b) Clinch River Water – The measured average concentrations and the percent of MPC_w of radionuclides in the Clinch River at Melton Hill Dam (CRM 23.1), about three miles upstream, at Gallaher (CRM 14.5), about six miles downstream, and at Center's Ferry (CRM 4.5), about 16 miles downstream from the entry of White Oak Creek, are given in Table 3.2.12, page 27.

(c) Potable Water – The average concentrations of ^{90}Sr in potable water at ORNL during 1972 were as follows:

Quarter Number	Concentration ^{90}Sr ($\mu Ci/ml$)
1	5.0×10^{-10}
2	3.9×10^{-10}
3	3.1×10^{-10}
4	4.1×10^{-10}
Average for year	4.0×10^{-10}

The average value of 4.0×10^{-10} represents 0.13 percent of the MPC_w for drinking water applicable to individuals in the general population. This ^{90}Sr concentration is about the same as that in Melton Hill Lake (Table 3.2.12, page 27) which is the source of this potable water.

(d) Radionuclides in Clinch River Fish – Several species of fish were sampled from the Clinch River during the spring and summer of 1972. The fish were prepared for radiochemical analysis in a manner analogous to human utilization. Ten fish of each species were composited and the samples were analyzed, by gamma spectrometry and radiochemical techniques, for the critical radionuclides contributing significantly to the potential radiation dose to man. The data are tabulated in pCi/kg of wet weight (Table 3.2.14, page 29) for each radionuclide of significance. An estimate of man's intake of radionuclides from eating the fish is made by assuming an annual rate of fish consumption of 14 pounds. An estimated percentage of maximum permissible intake is calculated by assuming a maximum permissible intake of fish to be comparable to a daily intake of 2.2 liters of water containing the MPC_w of these radionuclides for a period of one year.

(e) Silt Samples – Silt samples were collected from the bed of the Clinch River at points upstream and downstream from the confluence with White Oak Creek. The specific activities of ^{60}Co, ^{106}Ru, and ^{137}Cs were about one-third of those found in the last sampling in the year 1969. The quantities of ^{90}Sr were about the same as those of 1969.

3.2.3 Background Measurements

Background measurements were made each five weeks at a number of locations (established in 1961) in the East Tennessee area. The average background level during 1972, as measured at these stations, was 10 μR/hr. Average background readings and the location of each station are presented in Table 3.2.15, page 30.

3.2.4 Environmental Monitoring Samples

A listing of environmental monitoring samples processed by type sample, type of analyses, and number of samples is given in Table 3.2.16, page 31.

3.3 Health Physics Instrumentation

The Health Physics Division shares with the Instrumentation and Controls Division the responsibility for the selection of electronic radiation monitoring instruments used in the ORNL health physics program. Normally, the Health Physics Division is responsible for determining the need for new instrument types and modifications to existing types, for specifying the health physics requirements, and for approval of the design. The Health Physics Division is also responsible for calibrating all instruments used in the health physics program and is allocated the funds for maintenance of these instruments. Maintenance is performed or cross-ordered by the Instrumentation and Controls Division.

Non-electronic personnel monitoring devices are designed, tested, calibrated and maintained by Health Physics Division personnel.

3.3.1 Instrument Inventory

The electronic instruments used in the health physics program are divided, for convenience in servicing and calibrating, into two classes: the first class includes battery-powered portable instruments; the second class includes the stationary instruments that are AC powered. Portable instruments are assigned and issued to the Radiation and Safety Surveys Complexes. Stationary instruments are the property of the ORNL division which has the monitoring responsibility in the area in which the instrument is located. Table 3.3.1, page 32, lists portable instruments assigned at the end of 1972; Table 3.3.2, page 32, lists stationary instruments at the X-10 site in use at the end of 1972.

There was a decrease of 15 stationary instruments and a decrease of 11 portable instruments during the year.

Inventory and Service Summaries for health physics instruments are prepared on an IBM 360. These computer-programmed reports enable the Instruments Group to maintain a current inventory on most health physics instrument requirements.

The allocation of stationary health physics monitoring instruments at the X-10 site by division is shown in Table 3.3.3, page 33.

3.3.2 Calibration Facility

The Health Physics Division maintains a calibration facility for the calibration and maintenance of portable radiation instruments and personnel metering devices. The facility is equipped with calibration sources, remote control devices, and shop space for the use of Instrumentation and Controls Division maintenance personnel. Health Physics personnel assign, arrange for maintenance of, calibrate, provide delivery services for, and maintain inventory and servicing data of all portable health physics instruments.

Portable instruments should be serviced (1) whenever repairs are needed, (2) at least once each two months for those which have replacement-type batteries, and (3) at least once each three months for those instruments which have "permanent" (rechargeable) batteries. The number of calibrations of portable instruments for 1972 is shown in Table 3.3.4, page 34.

Table 3.1.1 Dose Data Summary for Laboratory Population Involving Exposure to Whole Body Radiation—1972

Group	Number of Rem Doses in Each Range							Total
	0-1	1-2	2-3	3-4	4-5	5-6	6 up	
ORNL Employees	4719	78	13	2	7	0	0	4819
ORNL-Monitored Non-Employees	89	0	0	0	0	0	0	89
TOTAL	4808	78	13	2	7	0	0	4908

Table 3.1.2 Average Rem Per Year Since Age 18—1972

	Number of Doses in Each Range				Total
	0-2.5	2.5-5.0	5.0-7.5	7.5 up	
ORNL Employees	4813	6	0	0	4819

Table 3.1.3 Average Rem Per Year of Employment at ORNL—1972

	Number of Doses in Each Range				Total
	0-2.5	2.5-5.0	5.0-7.5	7.5 up	
ORNL Employees	4805	14	0	0	4819

Table 3.1.4 Average of the Ten Highest Whole Body Doses and the Highest Individual Dose by Year

Year	Average of the Ten Highest Doses (Rem)	The Highest Dose (Rem)
1968	4.11	4.71
1969	2.84	3.79
1970	2.79	4.04
1971	3.41	4.95
1972	4.18	4.88

Table 3.1.5 Personnel Meter Services

	1970	1971	1972
A. Pocket Meter Usage			
1. Number of Pairs Used			
ORNL	95,524	96,668	79,976
CPFF	12,844	8,528	3,796
Total	108,368	105,196	83,772
2. Average Number of Users per Quarter			
ORNL	998	907	915
CPFF	143	132	86
Total	1,141	1,039	1,001
B. Film Usage			
1. Films Used in Photo-Badge-Meters			
Beta-Gamma	19,710	18,400	18,100
NTA	9,760	9,110	8,960
2. Films Used in Temporary Meters			
Beta-Gamma	5,800	6,700	5,810
NTA	1,880	2,170	1,880
C. Films Processed for Monitoring Data			
1. Beta-Gamma	20,700	19,500	19,050
2. NTA	1,230	1,110	1,250
3. Hand Meter	970	1,480	700

Table 3.1.6 Radiochemical Lab Analyses—1972

Radionuclide	Urine	Feces	Milk	Soil	Other	Controls
Plutonium, Alpha	764	13		18		250
Transplutonium, Alpha	556	27				250
Uranium, Alpha	306			18		50
Strontium, Beta	389	18	428			50
Cesium-137	25					
Tritium	58					25
Iodine-131			428			50
Other	72	6			50	
TOTALS	2170	64	856	36	50	675

Table 3.1.7 Counting Facility Analyses—1972

Types of Samples	Number of Samples			Unit Total
	Alpha	Beta	Gamma	
Facility Monitoring				
Smears	54,651	56,036		110,687
Air Filters	18,726	18,489		37,215
Environs Monitoring				
Air Filters	2,987	2,987		5,974
Fallout		1,868		1,868
Rainwater		1,650		1,650
Surface Water	62	153		215
Milk			428	428

Table 3.2.1 Concentration of Beta Radioactivity in Air—1972
(Filter Paper Data—Weekly Average)

Station Number	Location	Long-Lived Activity 10^{-14} µCi/cc
	Laboratory Area	
HP-1	S 3587	11
HP-2	NE 3025	16
HP-3	SW 1000	10
HP-4	W Settling Basin	16
HP-5	E 2506	19
HP-6	SW 3027	13
HP-7	W 7001	11
HP-8	Rock Quarry	12
HP-9	N Bethel Valley Road	11
HP-10	W 2075	13
HP-16	E 4500	12
HP-20	HFIR	14
Average		13
	Perimeter Area	
HP-31	Kerr Hollow Gate	7.1
HP-32	Midway Gate	8.0
HP-33	Gallaher Gate	7.4
HP-34	White Oak Dam	7.1
HP-35	Blair Gate	8.7
HP-36	Turnpike Gate	11
HP-37	Hickory Creek Bend	6.2
HP-38	E EGCR	6.9
HP-39	Townsite	8.9
Average		7.9
	Remote Area	
HP-51	Norris Dam	7.6
HP-52	Loudoun Dam	8.7
HP-53	Douglas Dam	8.1
HP-54	Cherokee Dam	8.4
HP-55	Watts Bar Dam	9.5
HP-56	Great Falls Dam	9.8
HP-57	Dale Hollow Dam	7.3
HP-58	Knoxville	7.8

Table 3.2.2 Concentration of Beta Radioactivity in Air
as Determined from Filter Paper Data—1972
(System Average - by Weeks)

Week Number	Units of 10^{-14} μCi/cc			Week Number	Units of 10^{-14} μCi/cc		
	LAM's	PAM's	RAM's		LAM's	PAM's	RAM's
1	8.8	5.5	4.7	29	15.0	8.8	10.0
2	4.2	3.3	2.6	30	9.0	5.9	6.1
3	96.0	62.6	78.9	31	5.7	3.5	3.7
4	15.0	5.5	10.6	32	5.9	4.3	4.4
5	14.0	5.8	5.7	33	6.6	4.4	4.3
6	12.0	7.6	10.0	34	7.7	5.5	4.6
7	20.0	5.8	6.3	35	5.6	3.5	3.7
8	16.0	7.3	6.7	36	9.6	5.1	5.3
9	9.6	4.3	5.2	37	8.8	5.4	4.5
10	38.0	6.5	7.0	38	7.8	4.9	4.7
11	14.0	8.7	9.2	39	7.5	5.9	4.3
12	9.4	4.5	4.0	40	4.7	3.3	3.3
13	13.0	7.5	9.5	41	6.6	3.9	4.2
14	16.0	10.0	8.0	42	5.6	7.6	4.3
15	8.4	10.0	9.0	43	3.7	2.8	3.3
16	25.0	15.0	17.0	44	3.2	1.7	1.8
17	23.0	15.0	9.6	45	3.6	2.6	2.7
18	15.0	11.0	10.0	46	4.3	1.9	2.2
19	14.0	7.8	10.0	47	9.2	3.6	3.3
20	9.9	7.6	7.8	48	4.0	2.4	2.3
21	8.8	6.6	7.1	49	2.9	1.7	1.1
22	19.0	13.0	14.0	50	4.7	1.6	2.2
23	26.0	19.0	19.0	51	1.6	1.0	0.6
24	31.0	22.0	21.0	52	4.0	1.2	0.9
25	22.0	13.0	16.0	53	1.8	0.9	0.5
26	23.0	16.0	21.0				
27	19.0	13.0	13.0				
28	21.0	13.0	14.0	Average	13.0	7.9	8.4

Table 3.2.3 Radioparticulate Fallout—1972
(Gummed Paper Data—Station Weekly Average)

Station Number	Location	Long-Lived Beta Activity 10^{-4} $\mu Ci/ft^2$	Total[a] Particles Per Sq. Ft.
	Laboratory Area		
HP-1	S 3587	1.3	0.68
HP-2	NE 3025	0.37	0.70
HP-3	SW 1000	0.58	0.46
HP-4	W Settling Basin	1.6	0.91
HP-5	E 2506	1.1	1.1
HP-6	SW 3027	0.85	0.79
HP-7	W 7001	0.35	0.68
HP-8	Rock Quarry	2.8	0.75
HP-9	N Bethel Valley Road	3.4	0.68
HP-10	W 2075	0.60	0.85
HP-16	E 4500	0.69	0.66
HP-20	HFIR	1.3	1.2
Average		1.2	0.79
	Perimeter Area		
HP-31	Kerr Hollow Gate	0.44	0.51
HP-32	Midway Gate	0.53	0.54
HP-33	Gallaher Gate	0.39	0.28
HP-34	White Oak Dam	1.3	1.6
HP-35	Blair Gate	1.8	0.55
HP-36	Turnpike Gate	2.3	0.64
HP-37	Hickory Creek Bend	0.58	0.81
HP-38	E EGCR	0.59	0.57
HP-39	Townsite	1.1	0.66
Average		0.99	0.68
	Remote Area		
HP-51	Norris Dam	0.26	0.32
HP-52	Loudoun Dam	0.29	0.70
HP-53	Douglas Dam	0.24	0.38
HP-54	Cherokee Dam	0.96	0.75
HP-55	Watts Bar Dam	0.32	0.36
HP-56	Great Falls Dam	0.83	0.75
HP-57	Dale Hollow Dam	0.53	1.1
HP-58	Knoxville	0.49	0.27
Average		0.49	0.57

Table 3.2.4 Radioparticulate Fallout Measurements[a] as Determined by Autoradiographic Techniques—1972 (Gummed Paper Data - System Average by Weeks)

Week Number	Particles/ft^2			Week Number	Particles/ft^2		
	LAM's	PAM's	RAM's		LAM's	PAM's	RAM's
1				29			0.25
2				30	0.17		
3	7.7	4.8	3.0	31	0.08	0.11	
4	0.17	0.22		32			
5		0.11		33	0.25		
6				34	0.25		
7				35	0.08		
8				36			
9		0.11		37			
10	0.08			38			
11	0.08			39			
12				40	0.17		
13	15.9	15.3	10.0	41			
14	1.3	1.9	0.63	42			
15	0.58	2.7	5.8	43	0.42		
16	2.1	1.1	2.3	44			
17	4.0	4.0	4.3	45	0.08		
18	0.25	0.22		46	0.08		
19	3.7	2.6	1.5	47			
20	2.3	1.6	1.4	48	0.17		
21	0.17	0.89	0.75	49	0.08		
22	0.67		0.75	50	0.08		
23	0.25	0.22	0.25	51			
24	0.42	0.11		52			
25		0.11		53			
26							
27	0.08	0.11					
28				Average	0.79	0.68	0.57

[a]Detection limit - 10^4 d/24 hr per particle.

Blank entries are zero.

Table 3.2.5 Concentration of Beta Radioactivity in Rainwater—1972
(Weekly Average by Stations)

Station Number	Location	Activity in Collected Rainwater, 10^{-8} μCi/ml
	Laboratory Area	
HP-7	West 7001	1.8
	Perimeter Area	
HP-31	Kerr Hollow Gate	1.4
HP-32	Midway Gate	1.4
HP-33	Gallaher Gate	1.8
HP-34	White Oak Dam	1.5
HP-35	Blair Gate	3.5
HP-36	Turnpike Gate	1.2
HP-37	Hickory Creek Bend	1.5
HP-38	E EGCR	2.3
HP-39	Townsite	1.3
Average		1.8
	Remote Area	
HP-51	Norris Dam	2.2
HP-52	Loudoun Dam	1.9
HP-53	Douglas Dam	3.7
HP-54	Cherokee Dam	2.6
HP-55	Watts Bar Dam	2.0
HP-56	Great Falls Dam	2.3
HP-57	Dale Hollow Dam	1.7
HP-58	Knoxville	1.5
Average		2.2

Table 3.2.6 Weekly Average Concentration of Beta Radioactivity in Rainwater—1972 (Units of 10^{-8} μCi/ml)

Week Number	LAM's	PAM's	RAM's	Week Number	LAM's	PAM's	RAM's
1	1.4	1.3	1.8	29	3.6	2.8	4.2
2	0.7	1.4	0.7	30	*	*	3.0
3	*	3.5	6.2	31	6.4	2.8	3.8
4	0.6	0.9	1.5	32	3.3	3.0	2.6
5	1.5	1.8	1.9	33	1.5	0.8	1.6
6	1.1	1.1	2.2	34	*	*	*
7	0.8	0.8	1.2	35	*	*	2.4
8	1.8	1.8	2.6	36	0.9	1.8	1.4
9	3.8	2.4	2.9	37	*	*	1.7
10	1.2	1.2	1.4	38	1.3	1.8	1.8
11	2.1	1.7	1.9	39	*	*	1.7
12	1.9	1.5	1.2	40	0	0.7	1.2
13	4.5	4.0	5.5	41	0.5	0.4	0.3
14	*	4.8	19.6	42	1.4	1.2	0.6
15	4.3	14.5	5.9	43	0.7	0.7	1.1
16	1.8	3.5	3.7	44	0.1	0.7	0.7
17	2.1	2.2	2.0	45	0	0.7	1.5
18	*	*	*	46	0	0	0.1
19	2.4	2.4	2.9	47	1.1	0.8	0.8
20	1.4	1.5	2.6	48	1.4	0.7	0.7
21	*	2.8	7.0	49	0.5	0.2	0.2
22	*	*	4.2	50	0	0	0
23	*	3.4	2.8	51	0	0	0
24	1.3	4.0	5.6	52	0.3	0.3	0.6
25	1.2	2.1	2.5	53	0.5	0.2	0.5
26	*	*	1.3				
27	3.2	3.0	3.5				
28	1.5	1.8	2.1	Average	1.8	1.8	2.2

*No rainfall.

Table 3.2.7 Weekly Average Concentration of ^{131}I in Air—1972
(Units of 10^{-14} μCi/cc)

Week Number	LAM's	PAM's	Week Number	LAM's	PAM's
1	2.8	1.3	29	3.2	0.9
2	2.5	1.1	30	1.7	0.8
3	7.6	4.6	31	2.9	0.8
4	3.5	1.5	32	2.7	0.7
5	2.4	0.8	33	3.8	1.3
6	5.2	2.0	34	4.5	1.1
7	10.1	0.8	35	2.7	0.8
8	4.3	0.8	36	4.9	1.0
9	2.7	0.8	37	3.7	0.6
10	3.6	0.8	38	3.4	0.9
11	4.8	0.8	39	4.4	0.8
12	2.8	0.8	40	1.8	0.6
13	3.1	0.9	41	2.9	0.7
14	3.3	1.0	42	2.4	1.4
15	4.4	0.8	43	3.9	1.3
16	2.9	0.8	44	3.2	0.7
17	3.3	0.7	45	2.3	0.7
18	2.2	0.7	46	3.4	0.8
19	3.4	1.0	47	4.8	0.9
20	2.9	1.0	48	4.1	0.8
21	4.7	0.9	49	3.8	1.0
22	4.2	1.0	50	7.5	0.9
23	3.9	1.2	51	6.5	0.6
24	2.6	0.7	52	4.5	1.0
25	2.4	0.9	53	4.0	1.0
26	4.0	2.2			
27	4.7	1.4			
28	1.4	0.6	Average	3.7	1.1

Table 3.2.8 Concentration of ^{131}I in Raw Milk—1972
(Units of pCi/l)

Quarter	Near ORNL		Remote from ORNL	
	Average*	Maximum	Average*	Maximum
1	3.7-12.5	54	11.6-20.5	104
2	4.8-12.9	130	2.4-10.5	14
3	0 -10.0	10	0 -10	10
4	0 -10.0	10	0 -10	10
Annual	1.7-11.4		3.3-13.3	

*See text, paragraph 3.2.1(e).

Table 3.2.9 Concentration of ^{90}Sr in Raw Milk—1972
(Units of pCi/l)

Quarter	Near ORNL		Remote from ORNL	
	Average	Maximum	Average	Maximum
1	11	29	12	23
2	12	24	9.4	13
3	11	26	8.6	13
4	9	18	5.4	8
Annual	11		8.6	

Table 3.2.10 Discharge of ^{131}I from ORNL Stacks—1972*

Stack Number	Curies	
	Total for Year	Monthly Average
2026	0	0
3039	1.1	0.09
3020	0	0
7512	0	0
7911	0.6	0.05
Total	1.7	0.14

*Data furnished by Operations Division.

Table 3.2.11 Yearly Discharges of Radionuclides to Clinch River (Curies)

	Year	^{137}Cs	^{106}Ru	^{89}Sr	^{90}Sr	TRE	^{95}Zr	Ce	^{95}Nb	I	Trans U Alpha	Co	^{3}H
26.8 (40.1)	1967	2.7	17	.7	5.1	8.5	0.49	.2	0.49	.9	1.0	3	13300
9.5	1968	1.1	5		2.8	4.4	0.27		0.27		0.04		9700
6.8	1969	1.4	1.7		3.1	4.6	0.18		0.18		0.2		12200
7.5	1970	2.0	1.2		3.9	4.7	0.02		0.02		0.4		9500
4.9	1971	0.9	0.5		3.4	2.9	0.01		0.01		0.05		8900
Σ 8.8	1972	1.7	0.52		6.5	5	0.01		0.01		0.05		10600

*Tri-Valent Rare Earths.

Table 3.2.12 Radioactivity in Clinch River—1972

Location	Concentration of Radionuclides of Primary Concern Units of 10^{-9} μCi/ml				% MPC_w
	^{90}Sr	^{137}Cs	^{106}Ru	^{3}H	
Melton Dam[a]	0.5	0.1	0.6	<1000	0.18
Clinch River at White Oak Creek[b]	0.6	0.1	0.1	1160	0.26
Gallaher[a]	1.5	0.7	0.8	<1880	0.58
Center's Ferry[a]	1.1	0.5	0.6	<1620	0.48

[a]Measured values.

[b]Values given for this location are calculated values based on the concentrations of wastes released from White Oak Dam and the dilution afforded by the Clinch River; they do not include radioactive materials (e.g., fallout) that may enter the River upstream from CRM 20.8.

Table 3.2.13 Calculated Percent MPC_w of ORNL Radioactivity Releases in Clinch River Water Below the Mouth of White Oak Creek—1972

Month	% MPC_w
January	0.27
February	0.31
March	0.37
April	0.38
May	0.21
June	0.16
July	0.19
August	0.15
September	0.17
October	0.42
November	0.26
December	0.58
Average	0.26

Table 3.2.14 Radionuclide Content of Clinch River Fish—1972

Species	pCi/kg Wet Weight		Estimated % MPI
	^{90}Sr	^{137}Cs	
White Crappie	62	185	0.18
Carp	35	43	0.10

Table 3.2.15 Background Radiation
in East Tennessee Area—1972

Stations	μR/hr
Great Falls	8.5
Dale Hollow	10.9
Crossville	8.0
Watts Bar	10.1
Rockwood	8.4
Wartburg	8.9
Kingston	9.9
Oliver Springs	12.4
Lenoir City	9.7
Clinton	10.4
Norris	9.5
Powell	13.4
Halls Cross Roads	11.1
Strawberry Plains	9.8
Cherokee	9.0
Average	10.0

Table 3.2.16 Environmental Monitoring Samples—1972

Sample Type	Type of Analyses	Number Samples
Monitoring network filters	Gross beta, autoradiogram	1738
Gummed paper fallout trays	Gross beta, autoradiogram	1525
Rainwater	Gross beta	783
White Oak Dam effluent	Gross beta, radiochemical, gamma spectrometry	432
Clinch River water	Gross beta, radiochemical gamma spectrometry	12
Raw milk	Radiochemical	428
Potable water	Radiochemical, gamma spectrometry	4
Soil Samples	Radiochemical, Plutonium and Uranium	9

Table 3.3.1 Portable Instrument Inventory—1972

Instrument Type	Instruments Added 1972	Instruments Retired 1972	In Service Jan. 1, 1973
G-M Survey Meter	3	13	469
Cutie Pie	0	4	424
Alpha Survey Meter	4	1	263
Neutron Survey Meter	0	0	104
Miscellaneous	0	0	27
TOTAL	7	18	1287

Table 3.3.2 Inventory of Facility Radiation Monitoring Instruments for the Year—1972

Instrument Type	Installed During 1972	Retired During 1972	Total Jan. 1, 1973
Air Monitor, Alpha	0	3	99
Air Monitor, Beta	0	2	177
Lab Monitor, Alpha	2	1	168
Lab Monitor, Beta	0	3	210
Monitron	0	4	216
Other	2	6	124
TOTAL	4	19	994

Table 3.3.3 Health Physics Facility Monitoring Instruments
Divisional Allocation at X-10 Site—1972

ORNL Division	α Air Monitor	β Air Monitor	α Lab Monitor	β Lab Monitor	Monitron	Other	Total
Analytical Chemistry	6	14	16	19	15	6	76
Chemical Technology	48	49	64	33	39	33	266
Chemistry	9	9	19	24	19	8	88
Metals and Ceramics	11	6	14	4	5	10	50
Isotopes	14	28	24	45	53	20	184
Operations	2	51	6	29	63	19	170
All Others	9	20	25	56	22	28	160
TOTAL	99	177	168	210	216	124	994

Table 3.3.4 Calibrations Résumé—1972

	1971	1972
Portable Instruments Calibrated		
Beta-Gamma	3,315	3,202
Neutron	369	370
Alpha	876	838
Pocket Chambers and Dosimeters	2,044	2,078
Films Calibrated	2,712	2,746

4.0 RADIATION AND SAFETY SURVEYS

4.1 Laboratory Operations Monitoring

During 1972 Radiation and Safety Surveys personnel assisted the operating groups in keeping the contamination, air concentration and personnel exposure levels well below the established maximum permissible limits. Through seminars, safety meetings and informal discussions with supervision, they assisted in reducing or eliminating a number of problems associated with radiation protection at the Laboratory. The following is a brief description of some of the problems and methods of solution.

4.1.1 Health Physics Participation in the LWBR Program, Building 3019

The Chemical Technology Division, over the next several years, is to produce several hundred kilograms of high purity $^{233}UO_2$ for use by Bettis Atomic Power Laboratory in the Light Water Breeder Reactor Program. Dissolver, solvent extraction purification, ion exchange purification and oxide conversion systems were operated in a series of test and qualification runs during the year. One hundred and seven Radiation Work Permits were certified and radiation surveys were performed for entries into the Pilot Plant cells and pipe tunnel for inspections, adjustments, repair or modifications to the equipment. Radiation surveys and measurements helped verify that the purified uranyl nitrate could be converted to $^{233}UO_2$ in the unshielded gloved boxes with personnel exposures well within permissible limits. Successful operation of all systems was achieved with good containment and personnel exposure control.

4.1.2 Surveys for Manipulator Decontamination and Repair, Building 3074

Master slave manipulators which cannot be repaired where installed are transferred to Building 3074. Many of these manipulators are grossly contaminated with fission products and/or transuranium elements necessitating decontamination in gloved boxes prior to repair operations. Radiation surveys were conducted for decontamination and repair of one hundred eighty-five manipulators. Decontamination procedures were continued in all cases until repairs could be performed with minimal protective apparel and without exceeding personnel exposure guides. Only occasional, minor contamination of the repair shop resulted.

A recommendation by Health Physics personnel to install water traps in the gloved box exhaust ducts was implemented, greatly extending the life of the HEPA exhaust filters.

4.1.3 Transfer of ^{233}U from NFS, Erwin, Tennessee, to Building 3019

ORNL was designated to ship and provide interim storage for scrap solids and liquids containing $\sim$ 18 kg of recoverable ^{233}U held at the Nuclear Fuel Services Plant in Erwin, Tennessee. Cell No. 1, Building 3019, was decontaminated using a high pressure jet of detergent solutions. Contamination was reduced to levels requiring only minimal protective apparel for cell renovation and installation of storage facilities. Representatives from the Health Physics and Chemical Technology Divisions spent over one month at the NFS Plant overseeing the packaging and providing radiation and contamination monitoring of the containers and shipments. Use of empty drum spacers and long wheel base tractors were necessary in some cases to meet DOT radiation limits for exclusive use shipments. All material was transferred to Cell No. 1 storage without incident.

4.1.4 Addition of the UNISOR to ORIC, Building 6000

The University Isotope Separator (UNISOR) was installed in the South Annex and became operational during 1972. "On line" (separation of isotopes produced by the ORIC beam) and "off line" (separation of other isotopes) operations were conducted on a limited basis. Containment features were added to the separator vacuum system and the "off line" ion source room prior to operation.

4.1.5 Installation of the 0.4 MV Sames Accelerator in Building 6025 (Neutron Physics Laboratory)

A 0.4 MV Sames positive ion accelerator was installed and became operational during 1972. The accelerator is to be used as a neutron source for calibration of instruments and in neutron transmission studies.

4.1.6 Operation in Metals and Ceramics Division, Building 4508

Twelve fuel pins were filled with ^{233}U in Lab 3, Room 265 of Building 4508. The operation involved gram quantities of ^{233}U and was carried out in glove boxes, and was performed without exposure to personnel or contamination of equipment outside of the boxes.

4.1.7 Health Physics Assistance during the Design and Construction of the High Level Tritium Handling Facility in Building 4505

Assistance was given by Health Physics personnel to the Chemical Technology Division in the planning and construction of a glove box operation involving $\sim$ 100 Ci of tritium gas. The minimizing of personnel exposure to the gas was enhanced through proper ventilation in the work areas and inside the box, emergency shut-down procedures, and bag-out ports. Area and personnel monitoring procedures were also established.

4.1.8 Decontamination and Renovation of Cell 1, Building 4507

Health Physics assistance and consultation was provided for the removal of obsolete, contaminated equipment and the decontamination of Cell 1, Building 4507. Radiation levels of up to 30 R/hr and smears $> 20{,}000\ \beta,\gamma$ d/m were found inside the cell. Air suits and maximum contamination clothing with respiratory equipment were worn by personnel. A plywood air lock system was built at the cell opening for receiving bagged-out equipment and for the removal of outer contamination clothing. During the entire operation contamination was adequately contained and personnel exposures were maintained at < 1 rem/quarter as planned.

4.1.9 The Connection of the Building 4556 Filter Pit Ducting to the Main Header Duct from Building 4507

In order to improve the cell off-gas system to the cells in Building 4507, a supplemental blower system with filters was installed in Building 4556. The procedure for connecting the filter pit ducting to the main off-gas header from Building 4507 required the removal of nine four-foot sections of the old off-gas line and tying in the new system. Readings taken inside the header were 3 mrem/hr and 4,000 α d/m. Very extensive planning on the part of all divisions concerned with the procedure was carried out, minimizing personnel exposure and the spread of contamination.

A negative pressure was maintained on the header at all times as primary containment. To provide secondary containment a frame structure covered with plastic with a resealable opening in the roof was erected over the exposed off-gas header. Each section of the piping was blocked off, wrapped in plastic and removed to the burial ground for appropriate disposal. Employees wore air suits or maximum contamination clothing with respiratory equipment. The project was completed without incident.

4.1.10 Annual Survey of X-Ray Equipment

The annual X-ray survey was completed during the year. Currently, a total of 73 units are registered. Although most aspects of X-ray safety were considered, the review focused mainly on the following items: (1) Clear and adequate identification of X-ray machines and work areas in which the machines are located; (2) X-ray leakage around the machines and power supplies; (3) Operation and integrity of interlocks and other safety devices; (4) Identification of the person primarily responsible for X-ray machine and designated operators for same; and (5) Changes in equipment or experiments.

As a result of the survey, recommendations were made to replace the interlocks on one walk-in unit, replace burned out warning lights at two installations, increase the intensity of the lights at one installation and to provide more protection from the high voltage supply on an X-ray diffraction unit.

4.1.11 Survey of Microwave-Generating Equipment

A number of new pieces of equipment which generate microwaves was installed at the Laboratory during the year. Surveys and hazard evaluations were made for these installations. Canteen microwave ovens were replaced by new models which are much less prone to have microwave leaks around the doors than the older models.

These ovens were surveyed quarterly during the year and microwave leakage was found to be well below the limits specified in OSHA.

4.1.12 Transuranium Research Laboratory, Building 5505

Protective and technical assistance was provided to individual TRL researchers in planning and conducting various experiments with transuranium isotopes. General areas of investigation in 1972 included: (1) Energetics and Theory, (2) Preparation and Properties of Solids, (3) Solution Chemistry, (4) Analytical Chemistry, (5) Super-heavy Elements, (6) Nuclear Spectroscopy and Reactions, (7) Fission Studies, and (8) Neutron Cross Section Studies.

In addition to providing safety training for permanent TRL research staff and new and visiting researchers, TRL Health Physics and Safety personnel responded to a number of requests for orientation and training lectures and demonstrations to other groups including: high school science clubs, University of Tennessee Graduate Chemistry Seminar class, ORAU Health Physics Training Course, and three other societies interested in radiation protection measures.

4.1.13 Modification and Repair of Processing Equipment in the TRU Facility, Building 7920

Extensive modifications to the processing systems and repairs to the equipment in TRU were conducted in 1972. The levels of radiation in the cell pits necessitated the use of remote maintenance techniques, which prolonged the maintenance operations. Alpha contamination in the pits had increased an order of magnitude since the last repair period, but through close Health Physics surveillance and the cooperation of operating personnel, internal exposures were generally lower than during similar periods in previous years. External exposures were maintained well within permissible limits.

The TRU Facility will be fully operational in the first quarter of 1973 and will continue to recover hundreds of milligrams of ^{252}Cf as well as other heavy elements from the HFIR target rods. These elements are then prepared for neutron source material for industry and research.

4.1.14 Applied Health Physics and Safety Activities at DOSAR, Building 7710, and Low Energy Accelerator, Building 7712

During April, 1972, the Health Physics Research Reactor core was removed, disassembled and inspected. The radiation level of the core plates were such as to require continuous Health Physics surveillance during the operation. Personnel exposures were kept to less than the recommended quarterly limits and there were no unusual occurrences involving radioactive materials.

The DOSAR Low Energy Accelerator (DLEA) was disassembled during July, 1972, and is being rebuilt. The possibility of the spread of tritium contamination required close Health Physics surveillance of the personnel and equipment involved.

4.1.15 Transfer and Handling of ORELA Foils at the TURF Facility, Building 7930

Radiation and Safety Surveys personnel monitored and assisted in the transfer and handling of irradiated ORELA foils in A cell and the irradiation of thermocouples in B cell. Survey personnel also assisted in removal of solid radioactive waste to the disposal area and the transfer of ^{252}Cf sources and samples from G cell to the TRU Facility.

4.1.16 Applied Health Physics and Safety Assistance on Salient Items Conducted at HFIR, Building 7900

Health Physics services were provided during certain phases of the operation of the HFIR as noted below:

1. Reactor shutdown inspection and maintenance.
2. Installation and removal of experiments in the core region.
3. Control plate drive rod replacement and maintenance.
4. Pneumatic tube neutron activation analysis operations and maintenance.
5. Primary coolant pump and heat exchanger equipment maintenance.
6. Loading and transfer of irradiated target rods and irradiated isotopes.
7. Surveillance during beam tube experiments.

There were no unusual occurrences involving radioactive materials, and exposures to personnel were maintained well within maximum permissible limits.

4.1.17 Health Physics Coverage of the Radio-Isotopic Sand Tracer Project

In a continuation of a project instituted in 1967 a representative of the Radiation and Safety Surveys Section again acted as project health physicist at the Radio-Isotopic Sand Tracer Test conducted by the Technical Services Group of the Isotopes Division for the U. S. Corps of Engineers. One test was conducted at Point Mugu, California. The tests involved placing radioactive sand, tagged with $^{198-199}Au$, offshore and tracing its movement along the ocean floor by the use of a specially designed radiation detection system. The Health Physics representative provided on-the-job surveillance, served as custodian of radioactive materials as well as assuring that all Federal and State regulations pertaining to the use of radioactive materials were followed. The test was completed without any significant contamination and/or exposure problems.

4.1.18 Shift Coverage and General Area Surveys

(a) Shale Fracturing - Continuous monitoring was provided during the year for preparatory maintenance (installation of new drain lines, maintenance on pumps, cell maintenance, etc.) and during the eventual injections of approximately 320,000 gallons of intermediate level waste. Four injections were made during the latter part of the year. Although high radiation fields were encountered at times by ORNL and Halliburton personnel, particularly during maintenance, all personnel exposures were kept below maximum permissible levels. It may be interesting to note that approximately 80 percent of the total exposures were received during preparatory maintenance and 20 percent during the actual injections.

(b) Installation of New Liquid Waste Transfer Line - Monitoring was provided during the installation of the new liquid waste transfer line from the Melton Valley Pumping Station to the tank farm. Some radiation and contamination problems were encountered during the work, particularly at the pumping station and the tank farm. However, all exposures were kept below maximum permissible levels.

4.2 Unusual Occurrences

Radiation incidents are classified according to a severity index system developed over the past several years.[4] The method serves to index unusual occurrences according to degree of severity and permits a system of analysis regarding Applied Health Physics and Safety practices among Laboratory operations.

During 1972 there were 11 unusual occurrences recorded which represents an increase of one over the number reported for 1971 (Table 4.2.1, page 42). The number for 1972, 11, is approximately nine percent below the five-year average of 12 for the years 1968 through 1972. The frequency rate of unusual occurrences among Laboratory divisions involved (Table 4.2.2, page 43) is known to vary in relationship to the quantity of radioactive material handled, the number of radiation workers involved, and the radiation potential associated with a particular operation or facility.

Eight of the incidents reported during 1972 involved area contamination that was handled by the regular work staff without appreciable production or program loss. One incident involved the partial shutdown of a facility with several man-hours of effort expended in the cleanup operation. Three occurrences involved personnel contamination requiring decontamination under medical supervision, and one occurrence required the establishment of zoning procedures to regulate future exposures.

4.3 Laundry Monitoring

There were approximately 648,000 articles of wearing apparel monitored at the laundry during 1972. Approximately 10 percent were found contaminated. Of

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[4]See ORNL-3665, Applied Health Physics Annual Report for 1963, pp. 14-15.

339,874 khaki garments monitored during the year, 156 were found contaminated. The percentage of contaminated khaki garments has been about the same during the past three years.

There were 7,638 full-face respirators cleaned and monitored during the year. Of this number, 639 required additional decontamination measures prior to being placed back in service. Also, 6,019 cannisters were cleaned and monitored.

Table 4.2.1 Unusual Occurrences Summarized for the 5-Year Period Ending with 1972

	1968	1969	1970	1971	1972
Number of Unusual Occurrences Recorded	20	12	9	10	11
A. Number of incidents of minor consequence involving personnel exposure below MPE limits and requiring little or no cleanup effort	7	4	2	1	2
B. Number of incidents involving personnel exposure above MPE limits and/or resulting in special cleanup effort as the result of contamination	13	8	7	9	9
1. Personnel Exposures	9	6	2	3	4
a. Nonreportable overexposures with minor work restrictions imposed	9	6	1	3	4
b. Reportable overexposures with work restrictions imposed	0	0	1	0	0
2. Contamination of Work Area	13	8	6	9	9
a. Contamination that could be handled by the regular work staff with no appreciable departmental program loss	13	7	5	8	8
b. Required interdepartmental assistance with minor departmental program loss	0	1	1	1	1
c. Resulted in halting or temporarily deterring parts of the Laboratory program	0	0	0	0	0

Table 4.2.2 Unusual Occurrence Frequency Rate within the Divisions for the 5-Year Period Ending with 1972

Division	No. of Unusual Occurrences 1968	1969	1970	1971	1972	5-Year Total	Percent Lab. Total (5-Year Period)
Analytical Chemistry	4	1		1	1	7	11.3
Biology	1					1	1.6
Chemical Technology	5	4	2	1	1	13	21.0
Chemistry				1	1	2	3.2
Inspection Engineering			1			1	1.6
Plant and Equipment	1					1	1.6
Isotopes	6	2	3	4	5	20	32.3
Metals and Ceramics	1	1	1	1		4	6.5
Neutron Physics	2					2	3.2
Operations		2	2	2	2	8	12.9
Physics					1	1	1.6
Reactor		1				1	1.6
Solid State		1				1	1.6
TOTALS	20	12	9	10	11	62	100.0

5.0 SAFETY ENGINEERING AND SPECIAL PROJECTS

The safety record for 1972, though good by industry standards, was poor by comparison with our recent past performance. The severity rate for Disabling Injuries dropped but the frequency was the highest since 1965. Two divisional injury-free periods of 6+ and 4.5+ million hours were ended.

5.1 Accident Analyses

The Disabling Injury frequency rate for 1972 was 1.08 (1971 - 0.61; average 1962-71 - 0.93). The Disabling Injury history for ORNL for the seven-year period, 1966-72, is shown in Table 5.1.1, page 46. Frequency rates since Union Carbide began operating ORNL (1948) are shown in Table 5.1.2, page 47.

Eleven divisions did not have a Serious or Disabling Injury in 1972, and 13 divisions have accumulated more than 1,000,000 hours each without a Disabling Injury. Serious and Disabling Injury data for ORNL divisions are shown in Table 5.1.3, page 48.

A comparison of injury data for ORNL, Paducah, Y-12, and ORGDP for 1972 is shown in Table 5.1.4, page 49. Tables 5.1.5, 5.1.6, page 50, and 5.1.7, page 51, present 1972 ORNL injury data according to accident type, nature of injury, and part of body injured.

5.2 Summary of Disabling Injuries

Following are summaries of the seven Disabling Injuries experienced at ORNL in 1972:

Date of Injury - 1/24/72

A machinist was standing by a Bridgeport mill tightening the cutter with a screwdriver. As he adjusted his feet to apply more force, he stepped off the rubber mat with his left foot which landed on an oily spot. He slipped and fell, sustaining a low back strain. Time loss: 179 days.

Date of Injury - 4/11/72

A machinist was hand-polishing a piece of 3/4" tubing rotating at 250 rpm in a lathe. He wore a glove on his right hand to keep his hand clean. The emery cloth and glove snagged on the rotating piece, and the first joint of his right index finger was torn off. Time charge: 60 days.

Date of Injury - 6/21/72

A chemist, driving a van-type vehicle, struck a pickup which failed to stop at a stop sign. The chemist was thrown out of his vehicle (not using a seat belt). He suffered a cerebral concussion and abrasions to his knees and left arm. Time loss: 6 days.

Date of Injury - 6/30/72

A laboratory technician was entering the Plant on his way to work. He apparently stepped on a scrap of sheet metal, fell, and sustained a severely sprained left ankle. Time loss: 30 days.

Date of Injury - 10/16/72

A welder struck an arc against the side of a closed 30-gallon drum filled with cut styrofoam. An explosion inside the drum blew off the lid which struck him in the face and chest. Later it was found that this was a special batch of material for which a flammable foaming agent had been used. The welder suffered contusions of the chest, left forearm, and left temple. Time loss: 15 days.

Date of Injury - 10/20/72

A research scientist used a pen knife to pry the friction lid from a can of silica gel. The knife slipped and cut a tendon in his left thumb. Time loss: 6 days.

Date of Injury - 12/11/72

A technical illustrator stood on the 20"-high top step of a set of movable steps and threw a piece of glass in a large garbage container. As he turned, his feet became tangled and he fell down the steps, catching his weight on his hands and arms. He fractured his left wrist and right elbow. Time loss: 29 days.

5.3 Safety Awards

The Safety Incentive Plan, based on Serious as well as Disabling Injuries, was continued with awards being gift certificates from local stores. Four 1,000,000-hour injury-free periods were attained for a Plant-wide award of $4.00. Group awards varied from $4.00 to $6.00, making total earned awards of from $8.00 to $10.00. An increase of 15 percent in these amounts was negotiated with the gift certificate suppliers.

Table 5.1.1 Disabling Injury History—ORNL (1966-1972)

	1966	1967	1968	1969	1970	1971	1972
Number of Injuries	5	4	1	2	5	4	7
Labor Hours (Millions)	7.8	8.0	7.8	7.5	6.6	6.5	6.5
Frequency Rate	0.64	0.50	0.13	0.27	0.76	0.61	1.08
Days Lost or Charged	1212	1816	60	67	577	1944	337
Severity Rate	155	226	8	9	88	298	52

Table 5.1.2 ORNL Disabling Injury Frequency Rates Since Inception of Carbide Contract Compared with Frequency Rates for NSC,* AEC and UCC

Year	ORNL	NSC	AEC	UCC
1948	2.42	11.49	5.25	5.52
1949	1.54	10.14	5.35	4.91
1950	1.56	9.30	4.70	4.57
1951	2.09	9.06	3.75	4.61
1952	1.39	8.40	2.70	4.37
1953	1.43	7.44	3.20	3.61
1954	0.79	7.22	2.75	3.02
1955	0.59	6.96	2.10	2.60
1956	0.55	6.38	2.70	2.27
1957	1.05	6.27	1.95	2.41
1958	1.00	6.17	2.20	2.21
1959	1.44	6.47	2.15	2.16
1960	0.94	6.04	1.80	1.92
1961	1.55	5.99	2.05	2.03
1962	1.45	6.19	2.00	2.28
1963	1.55	6.12	1.60	2.10
1964	1.07	6.45	2.05	2.20
1965	2.34	6.53	1.80	2.40
1966	0.64	6.91	1.75	2.57
1967	0.50	7.22	1.55	2.06
1968	0.13	7.35	1.27	2.24
1969	0.27	8.08	1.52	2.49
1970	0.76	8.87	1.28	2.27
1971	0.61	9.37	1.44	2.05
1972	1.08	—	1.33	1.73

*National Safety Council (NSC), all industries.

Table 5.1.3 Injury Statistics by Division—1972

Division	Medical Treatment Cases	Serious Injuries No.	Serious Injuries Freq.	Disabling Injuries Number	Disabling Injuries Freq.	Disabling Injuries Sev.	Exposure Hours (In Millions)
Analytical Chemistry	13	1	4.35	1	4.34	26	.230
Chemical Technology	24	1	2.30	0			.436
Chemistry	4	1	6.25	0			.160
Director's	7	0		0			.177
Environmental Sciences	20	2	13.35	0			.150
Health Physics	12	1	3.51	0			.285
Instr. and Controls	31	2	4.32	0			.463
Mathematics	3	0		0			.278
Metals and Ceramics	23	4	8.88	1	2.22	66	.451
Neutron Physics	4	1	8.55	0			.117
Physics	4	0		0			.194
Reactor	0	0		0			.020
Reactor Chemistry	3	0		0			.121
Solid State	4	0		0			.124
General Engineering	3	0		0			.224
Health	1	0		0			.050
Information	9	2	8.42	1	4.21	122	.238
Isotopes	19	1	4.53	0			.221
Laboratory Protection	7	0		0			.153
Operations	43	2	5.42	0			.369
Personnel	20	2	13.80	0			.145
Plant and Equipment	544	27	16.43	3	1.82	162	1.645
Envr. Prog.	1	0		0			.049
Insp. Engr.	8	1	14.30	0			.070
MAN	1	1	14.50	1	14.55	87	.069
EISO	0	0	0.00	0			.026
PLANT TOTAL	808	49	7.58	7	1.08	52	6.467

Table 5.1.4 Four-Plant Tabulation of Injuries—1972

Plant	Labor Hours (Millions)	Disabling				Serious	
		Number of Injuries	Frequency Rate	Days Lost or Charged	Severity Rate	Number of Injuries*	Frequency Rate
ORNL	6.5	7	1.08	337	52	49	7.58
ORGDP	5.0	6	1.18	414	82	46	9.06
Y-12	13.4	1	.07	41	3	115	8.61
Paducah	2.4	3	1.34	461	205	26	11.59

ncludes the number of Disabling Injuries.

Table 5.1.5 Number of Accidents by Types

Type of Accident	Number of Accidents
Struck Against	325
Struck By	212
Slip, Twist, Overexertion	89
Caught In, On, or Between	72
Fall, Same Level	27
Fall, Different Level	8
Contact, Temperature Extremes	16
Inhalation, Absorption, Ingestion	6
Electrical	2
Other	49
TOTAL	806

Table 5.1.6 Number of Accidents by Nature of Injury

Nature of Injury	Number of Accidents
Laceration, Puncture	354
Contusion, Abrasion	147
Strain	90
Conjunctivitis	18
Sprain	13
Burn (Temperature)	50
Burn (Chemical)	7
Burn (Flash)	2
Fracture, Dislocation	12
Hernia	4
Other	109
TOTAL	806

Table 5.1.7 Number of Accidents Relative to Part of Body Injured

Body Area	Percentage	Total Injuries
Head	6.7	54
Eyes	6.2	50
Shoulder-Chest	4.6	37
Back	7.0	56
Arms	9.6	77
Hands	12.0	97
Fingers	37.4	302
Lower Trunk	3.1	25
Legs	7.7	62
Feet	4.3	35
Toes	.9	7
Other	.5	4
TOTAL	100.0	806

6.0 INFORMATIONAL ACTIVITIES

6.1 Visitors and Training Groups

During 1972 there were 104 visitors to Applied Health Physics and Safety, as individuals or in groups, for training purposes. Table 6.1.1 is a listing of training groups which consisted of five or more persons.

Table 6.1.1 Training Groups in Applied Health Physics and Safety Facilities during 1972

Facility	Number	Training Period
AEC Fellowship	7	6/19/72 - 7/21/72
University of Arkansas	5	5/9/72 - 5/11/72
Lenoir Rhyne College	5	1/25/72 - 1/26/72
ORAU Ten-Weeks H. P. Course	20	4/3/72 - 6/9/72[a]
ORAU Technician Training Course	15	8/14/72 - 8/22/72[a]

[a]Approximately 65 lecture and field training hours were contributed by ORNL personnel during the periods noted above.

6.2 Publications and Papers

C. J. Barton, H. M. Butler, R. B. Cumming, and P. S. Rohwer, "The 1971 Tritium Symposium at Las Vegas", Nuclear Safety, Vol. 13, No. 3, May-June, 1972.

H. M. Butler and R. E. Millspaugh, "Emergency Planning: Guidelines for Personnel Exposures and Contamination Limits", presented to the Tenth AEC-Sponsored Seminar on Medical Planning and Care in Radiation Accidents, Oak Ridge, Tennessee, May 21-24, 1972.

D. M. Davis, Applied Health Physics and Safety Annual Report for 1971, ORNL-4795, June, 1972.

Environmental Monitoring Report, United States Atomic Energy Commission, Oak Ridge Facilities, Calendar Year 1971, UCC-ND-221, Office of Safety and Environmental Protection (prepared by H. H. Abee, Health Physics Division), June 30, 1972.

C. B. Fulmer, H. M. Butler, and K. M. Wallace, "Radiation Leakage through Thin Cyclotron Shield Walls", Particle Accelerators, Vol. 4, pp. 63-68, December, 1972.

E. D. Gupton, D. M. Davis, and F. R. Bruce, The Safety Program of Oak Ridge National Laboratory, CF 72-10-49, October 1, 1972.

E. D. Gupton and P. E. Brown, "Chest Clearance of Inhaled Cobalt-60 Oxide", Health Physics, Vol. 23, pp. 767-769, 1972.

J. C. Hart, "Legal and Administrative Aspects of Personnel Dosimetry", Health Physics, Vol. 23, No. 3, pp. 343-348, September, 1972.

W. J. McDowell (Chemical Technology Division) and L. C. Henley, An Evaluation of the Possibility of Detecting and Identifying Alpha Emitters in Low-Count-Rate Samples Using Some New Liquid Scintillation Counting Techniques, ORNL TM-3676, March, 1972.

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